**BITS, PILANI-DUBAI**
**SECOND SEMESTER 2010-2011**
**ME C332 PRIME MOVERS AND FLUID MACHINES**
**Comprehensive Exam DATE: 26-05-11**
**DURATION: 3hrs MAXIMUM MARKS: 35 WEIGHTAGE: 35%**

***Notes: Steam tables are allowed.***
***Highlight all your answers by enclosing in boxes. Assume any missing data suitably and mention the same at the appropriate place in your answer. All the parts of the same question should be answered together.***

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1. Derive an expression for the thrust developed by a propeller which depends upon the angular velocity ω, approach velocity V, dynamic viscosity μ, density ρ, propeller diameter D and the compressibility of the medium measured by the local velocity of sound C. **3**

2. A pelton wheel has a jet of 150mm in diameter and works under a head of 450m .The wheel to jet ratio is 16 and runs at 360rpm.The buckets deflect the jet through an angle of 165°.Calculate the force exerted by the jet on buckets, power output and overall efficiency of the turbine. Take Cv for nozzle = 0.98, K=0.9, mechanical losses 3% of power developed by the runner. **5**

3. A single acting reciprocating pump has a piston of 30cm diameter and a stroke of 450 mm. The level of the water in the sump is 4m below the center line of the pump and the storage reservoir is 30m above the center line of the pump. The suction and delivery pipes are 10m and 120m long and are 125mm in diameter. Estimate the max speed of the pump in order to avoid separation. Take vapor pressure of water as 2.5 m and atmospheric pressure as 10.3 m of water. At this speed calculate the discharge of the pump in liters per minute. **5**

4. Explain how centrifugal pumps are classified. State the fundamental equation of the centrifugal pump and explain the various terms. **4**

5. A single stage double acting air compressor delivers 10 $m^3$ of free air per minute measured at 1.013 bar and temperature 27°C and delivers at 7 bar. The conditions at the end of the suction stroke are 0.98 bar and 40°C. The clearance is 4% of stroke volume and the stroke to bore ratio is 1.3. Compressor runs at 300 rpm. Calculate the cylinder dimensions and indicated power of the compressor. Take the index of compression and re expansion as 1.3. **5**

6. Prove that the velocity triangles are similar for 50% reaction turbine and show that the maximum efficiency for such a turbine is $[2\cos^2\alpha 1 / (1+ \cos^2\alpha 1)]$, where $\alpha 1$ is the angle at which the steam enters the blades. **4**

7. a. Explain surging and choking in rotary compressors with suitable graph.

   b. Explain the terms slip factor and pressure coefficient in rotary compressors. **4**

8. The blades of a free vortex gas turbine rotor have inlet and outlet angles of 30° and 25° at a mean diameter of 100cm.The corresponding nozzle angle is 20°.The hub-tip ratio is 0.6 and the turbine runs at 3600 rpm. Calculate for the hub and the mean sections of the blades a. the blade angles, b. the degree of reaction and c. the blade to gas speed ratio. **5**

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# TEST 2(Open book)

**DATE: 08-05-11**

**DURATION: 50 MINUTES MAXIMUM MARKS: 15 WEIGHTAGE: 15%**

**(Text book, photo copy of bound EDD notes, hand written class notes and steam tables are allowed)**

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1. A nozzle is supplied with steam at 8 bar and 200°C. The discharge takes place against a back pressure of 1 bar. Approach velocity is 75m/sec. The pressure at the throat is 4 bar. No frictional losses take place between the inlet and the throat. Determine the velocity at the throat. If the exit velocity is 742 m/sec, what is the overall efficiency of the nozzle? **5**

2. At a stage of a reaction turbine the steam enters the turbine with an absolute velocity of 341m/sec, the mean blade ring diameter is 1 m and turbine runs at 50rps.The blades are designed for 50% reaction with exit angle of 30° and inlet angle of 50°.The turbine is supplied with steam of 60000kg/hr and assuming similar velocity triangles determine the power output from the turbine and the blade or diagram efficiency of the turbine. . **5**

3. A three-stage single acting air compressor delivers 2 $m^3$ of free air per min at 100 bar. The ambient conditions are 1.03 bar and 20 °C. The suction conditions are 1 bar and 30 °C. Assuming perfect inter cooling between the stages find the indicated power of the compressor. If the clearance is the 5% of the stroke in all cylinders and common stroke is equivalent to the diameter of the lowest pressure cylinder find the diameters and strokes of all the cylinders. Take the index of compression and re expansion is 1.35 and speed of the compressor as 300 rpm. Neglect the pressure losses between the stages. **5**

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# TEST 1

**DATE: 20-03-11**

**DURATION: 50 MINUTES** **MAXIMUM MARKS: 15** **WEIGHTAGE: 15%**

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1. Define, give expression and explain the significance of the following Non dimensional numbers: Euler number, Froude number and Mach number.
   Define Unit speed and Specific speed of a turbine and explain the use of these parameters. **5**

2. Single jet Pelton turbine is required to drive a generator to develop 10MW. The available head at the nozzle is 760m. Assuming electrical generator efficiency of 95%, Pelton wheel efficiency of 87%, coefficient of velocity for the nozzle 0.97, mean bucket velocity 0.46 of jet velocity, outlet angle of the buckets is 15° and the blade velocity coefficient (K) as 0.85 find
   a. the diameter of the jet, b. the flow rate of water, and c. the force exerted by the jet on the buckets **5**

3. A single acting reciprocating pump has a plunger diameter of 200mm and a stroke of 300mm. The suction pipe is 100mm in diameter and 8m long. The water surface in the sump from which the pump draws water is 4m below the pump cylinder axis. If the pump is working at 30 rpm find the pressure head on the piston at the beginning, middle and end of the suction stroke. Take f=0.01 and Hatm = 10m of water. **5**

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**BITS, PILANI-DUBAI CAMPUS, KNOWLEDGE VILLAGE, DUBAI**
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## ME UC332 PRIME MOVERS AND FLUID MACHINES

## QUIZ2

**DURATION: 20 MINUTES MAXIMUM MARKS: 8 WEIGHTAGE: 5%**

**Answer all the questions**

Name of the student: ---------- Id.: ----------

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1. What do you mean by manometric head of a centrifugal pump?

2. What do you mean by connecting the centrifugal pumps in series and parallel? When the series connection is used and when the parallel connection is used?

3. What is critical pressure ratio in steam nozzles? Give an expression for the critical pressure ratio in terms of index of expansion.

4. What is Wilson line and what is the significance of it in steam nozzles?

5. Draw the pressure and velocity graph for a pressure compounded steam turbine.

6. Give an expression for the optimum speed ratio which gives the maximum efficiency in terms of nozzle angle and give an expression for the maximum work in terms of blade velocity for a single stage impulse steam turbine.

7. Steam expands in a nozzle from 5bar to 1 bar. The initial velocity is 100m/sec. The isentropic enthalpy drop for the steam is 200kJ/kg and the nozzle efficiency is 85%. Estimate the final velocity of the steam.

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# QUIZ1

**09-03-2011**

**DURATION: 20 MINUTES MAXIMUM MARKS: 10 WEIGHTAGE: 5%**
**Answer all the questions (5*2 = 10 marks)**

**Name:** **Id No. :**

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1 Determine the dimensions of thrust and dynamic viscosity.

2. Define the specific speed of a turbine and a pump.

3. Draw the speed versus discharge and speed versus efficiency curves for the Pelton and Francis turbine

4. A pelton turbine produces 25 MW while running at a speed of 1000rpm. If the hydraulic and mechanical efficiency of the turbine are 80% and 90% respectively, calculate the discharge through the turbine.

5. A Kaplan turbine works under a head of 10m and handles $180*10^3$ liters of water per second. If the flow ratio for the turbine is 0.65 and the diameter of the boss is 0.4 times the external diameter of the runner, calculate the diameter of the runner.